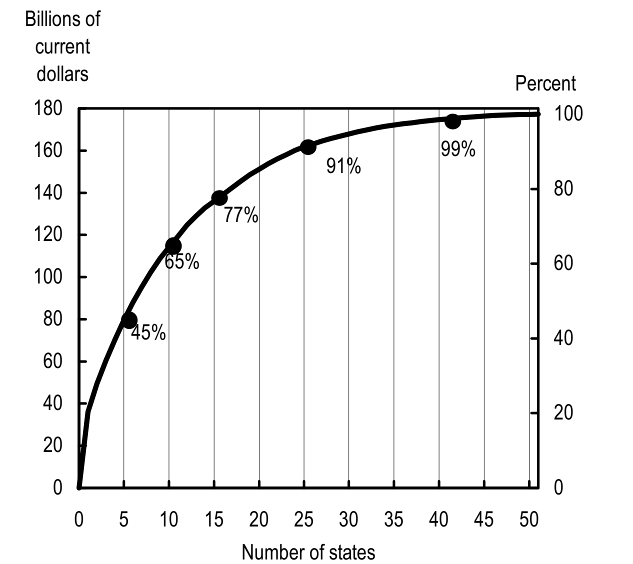
NATIONAL R&D PERFORMANCE PATTERNS—BY STATE

The latest data available on the state distribution of R&D performance are for 1995.[24] These data cover R&D performance by industry, academia, and Federal agencies, along with the federally funded R&D activities of nonprofit institutions.[25] The state data on R&D contains 52 records: the 50 states, the District of Columbia (DC), and "other/unknown" which accounts for R&D in Puerto Rico and other non-state U.S. regions, as well as R&D for which the particular state was not known. Approximately two-thirds of the R&D that could not be associated with a particular state is R&D performed by the nonprofit sector. Consequently, the distribution of R&D by state indicates primarily where R&D is undertaken in Federal, industrial, and university facilities.

In 1995, total R&D expenditures in the United States were $183 billion, of which $177 billion could be attributed to expenditures within individual states, with the remainder falling under an undistributed, "other/unknown" category. (See appendix table B-8.) The statistics and discussion below refer to state R&D levels in relation to the distributed total of $177 billion.

R&D is substantially concentrated in a small number of states. In 1995, California had the highest level of R&D expenditures—over $36 billion—representing approximately one-fifth of the $177 billion U.S. total. The six states with the highest levels of R&D expenditures—California, Michigan, New York, Massachusetts, New Jersey, and Texas (in descending order)—accounted for approximately one-half of the entire national effort. The top 10 states—adding, in descending order, Illinois, Pennsylvania, Maryland, and Ohio—accounted for nearly two-thirds of the national effort (figure 14 and text table 7). California's R&D effort exceeded, by nearly a factor of three, the next-highest state, Michigan, with $13 billion in R&D expenditures. After Michigan, R&D levels declined relatively smoothly to approximately $5 billion for Ohio. The 20 highest-ranking states in R&D expenditures accounted for about 85 percent of the U.S. total; the lowest 20 states, for 5 percent.

Figure 14. Cumulative distribution of U.S. R&D performance, by state: 1995



NOTE: Includes R&D expenditures for the District of Columbia but excludes R&D that cannot be distributed by state.

SOURCE: National Science Foundation/Division of Science Resources Studies, table B-8.

States that are highest in total R&D performance are usually ranked among the highest in both industrial and academic R&D performance. For example, among the top 10 for total R&D, eight states were among the top 10 for industrial R&D, and eight were among the top 10 for academic R&D, as shown in table 7.

For Federal intramural research, there was less commonality with the top 10 for total R&D. Only four states were found in both top-10 lists: Maryland, California, Ohio, and Texas. The six others in the Federal intramural list, in descending order of Federal R&D performance, were the District of Columbia, Virginia, Alabama, Florida, New Mexico, and New Jersey. Maryland ranked first among Federal R&D performers, followed by the District of Columbia, California, and Virginia. The placement of Maryland, the District of Columbia, and Virginia among the top four in Federal R&D performance reflects the concentration of Federal facilities and administrative

[24] Although annual data are available on the location of R&D performance by the academic and Federal sectors, NSF conducts surveys on the State distribution of industrial R&D performance only in odd-numbered years. At this writing, the 1997 industry R&D survey data have not been processed, making 1995 the most recent year for which the State-specific R&D totals can be reported.

[25] R&D performance data include the R&D activities in FFRDCs in each sector of the economy. For a more detailed description of these data, as well as comparisons of 1985 R&D expenditures with other economic measures (for example, population and gross state product), see NSF, *Geographic Patterns: R&D in the United States*, by John E. Jankowski, NSF 89-317 (Washington, DC, 1989).

Table 7. Leading states in total R&D performance, R&D by sector, and R&D as a percentage of gross state product (GSP): 1995

	Top 10 states in total R&D performance		Top 10 states in size of R&D, by type of performer			Top 10 states in R&D intensity (states having the highest R&D/GSP ratio)		
Rank	Total R&D [millions of current dollars]	Top 10 states 1/	Industry 2/	Universities & colleges 3/	Federal Government	Most R&D intensive	R&D/GSP [percent]	GSP [billions of current dollars]
1.........	$36,133	California	California	California	Maryland	New Mexico	8.09%	$40.76
2.........	13,275	Michigan	Michigan	New York	District of Columbia	District of Columbia	6.30	49.69
3.........	10,955	New York	New York	Illinois	California	Michigan	5.27	251.79
4.........	9,970	Massachusetts	New Jersey	Massachusetts	Virginia	Massachusetts	5.09	195.87
5.........	9,128	New Jersey	Massachusetts	Texas	Alabama	Maryland	5.00	137.35
6.........	8,385	Texas	Texas	New Mexico	Ohio	Delaware	4.26	26.95
7.........	7,486	Illinois	Illinois	Pennsylvania	Florida	California	3.96	913.47
8.........	6,919	Pennsylvania	Pennslyvania	Maryland	Texas	Connecticut	3.63	118.60
9.........	6,865	Maryland	Washington	Michigan	New Mexico	Rhode Island	3.58	25.05
10.......	5,315	Ohio	Florida	North Carolina	New Jersey	Washington	3.49	150.00

1/ Includes in-state R&D performance of industry, universities, associated federally funded research and development centers (FFRDCs), and Federal agencies and the federally funded R&D performance of nonprofit institutions. For these tabulations, "states" include the District of Columbia.

2/ Includes R&D activities of industry-administered FFRDCs located within these states.

3/ Includes R&D activities of university-administered FFRDCs located within these states.

SOURCES: National Science Foundation/Division of Science Resources Studies, tables B-7 and B-8, and Bureau of Economic Analysis.

offices within the national-capital area.[26] Alabama, Florida, and New Mexico rank among the highest in Federal R&D because of their relatively high shares of Federal space- and defense-related R&D.

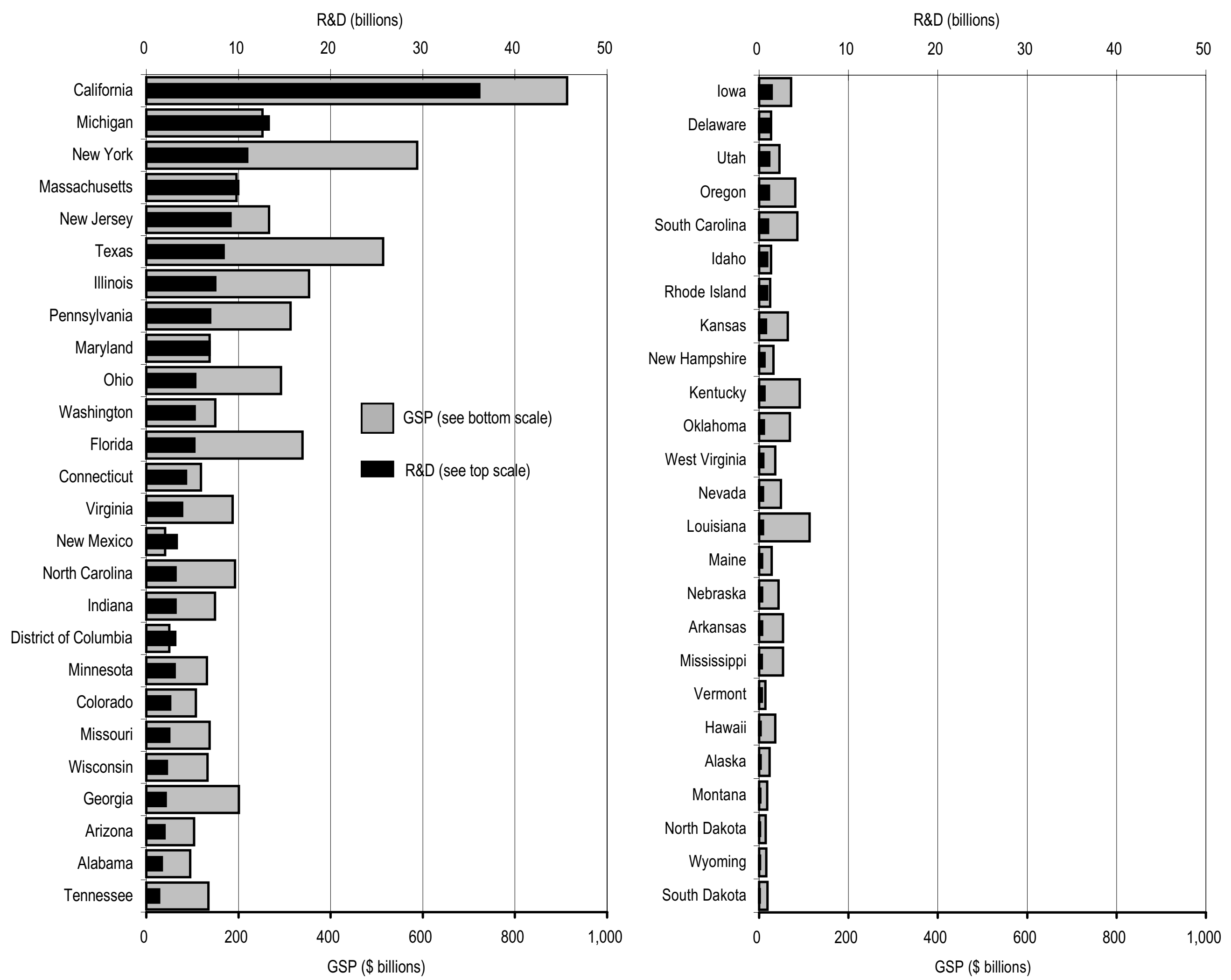
States vary widely in the size of their economies, owing to differences in population, land area, infrastructure, natural resources, and history. Consequently, variation in the R&D expenditure levels of states may simply reflect differences in economic size or the nature of their R&D efforts. A simple way of controlling for the size effect is to measure each state's R&D level as a proportion of its gross state product (GSP) (appendix table B-8). That proportion is referred to as R&D "intensity" or "concentration." Overall, the Nation's total R&D to gross domestic product ratio was 2.5 percent in 1995. The top 10 rankings for R&D intensity were, in descending order, New Mexico (8.1 percent), the District of Columbia, Michigan, Massachusetts, Maryland, Delaware, California, Connecticut, Rhode Island, and Idaho (the latter with an intensity of 3.5 percent). New Mexico's R&D intensity is largely attributable to Federal support to the Sandia National Laboratories and Los Alamos National Laboratory FFRDCs in the state, provided by the Department of Energy.

Figure 15 juxtaposes state R&D performance with GSP, with the 50 states and the District of Columbia ranked in descending order of R&D. R&D expenditures are displayed as a dark bar, measured on the upper axis; GSP is displayed as a wider gray bar measured on the lower axis; both are measured in billions of dollars. The two highest-ranked states in total R&D—California and Michigan—clearly show R&D levels that are relatively high in relation to their GSPs, as reflected by their presence in the top 10 list for R&D intensity (table 7).[27]

[26] Federal intramural performance included the administration of extramural R&D programs.

[27] For additional information about the geographic distribution of R&D within the United States, see National Science Foundation, *Science and Engineering State Profiles: 1997*, by Richard J. Bennof and Steven Payson, NSF 98-315 (Arlington, VA, 1998).

Figure 15. Relationship between the amount of R&D performed in a state and the size of its economy (GSP): 1995



NOTE: Includes R&D expenditures for the District of Columbia but excludes R&D that cannot be distributed by state. States are ranked by total R&D expenditures. GSP = gross state product.

SOURCE: National Science Foundation/Division of Science Resources Studies, table B-8.

Character of Work

The Nation spent an estimated $34.4 billion on the performance of basic research in 1998, $49.8 billion on applied research, and $136.4 billion on development (figure 16). These totals represent noticeable increases from preliminary estimates of 1997 levels: a 2.4-percent increase, in real terms, for basic research; a 6.2-percent increase for applied research; and a 5.8-percent increase for development. As a share of all 1998 projected R&D performance expenditures, basic research represents 15.6 percent, applied research 22.6 percent, and development 61.8 percent.

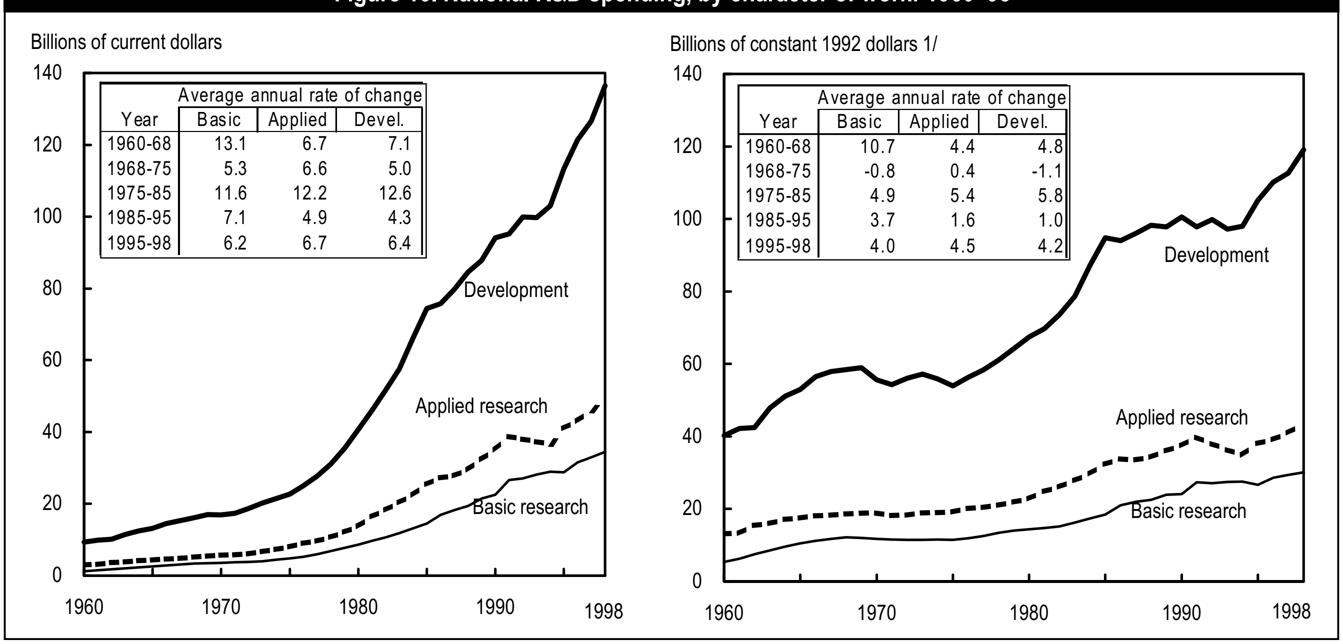
The expected 1998 percentage shares differ only slightly from those reported for 1980. Basic research then accounted for 13.7 percent, applied research for 21.8 percent, and development for 64.5 percent. The methodology for imputing character-of-work estimates for industry's R&D performance, however, was changed for 1986 and later years. Consequently, data after 1985 are not strictly comparable with data for 1985 and earlier years. The revised approach resulted in relatively higher estimates for basic and applied research and lower estimates for development expenditures. Furthermore, the improved sampling of industry's R&D activity beginning in 1992 also resulted in notably higher basic research estimates than had previously been represented. (See appendix A for further details.)

Basic Research

The average annual real growth in basic research performance was 5.2 percent between 1980 and 1985, 4.5 percent between 1985 and 1994, and 2.2 between 1994 and 1998 (by preliminary estimates for 1998).

In terms of support, the Federal Government provided the majority of funds used for basic research. However, the Federal share of funding for basic research dropped as a percent of all funding, from 70.4 percent in 1980 to a preliminary 56.7 percent ($19.5 billion) in 1998. This decline does not reflect a decline in Federal funding for basic research, which in fact, grew an estimated 3.0 percent per year in real terms between 1980 and 1998. Rather, the decline in the Federal share of basic research reflects an increased tendency for the funding of basic research to come from other sectors. Specifically, from 1980–98, non-federal support for basic research grew at the remarkable rate of 6.4 percent per year in real terms, by preliminary estimates.

Figure 16. National R&D spending, by character of work: 1960–98



Billions of current dollars — Average annual rate of change

Year	Basic	Applied	Devel.
1960-68	13.1	6.7	7.1
1968-75	5.3	6.6	5.0
1975-85	11.6	12.2	12.6
1985-95	7.1	4.9	4.3
1995-98	6.2	6.7	6.4

Billions of constant 1992 dollars 1/ — Average annual rate of change

Year	Basic	Applied	Devel.
1960-68	10.7	4.4	4.8
1968-75	-0.8	0.4	-1.1
1975-85	4.9	5.4	5.8
1985-95	3.7	1.6	1.0
1995-98	4.0	4.5	4.2

1/ Based on GDP implicit price deflator.

SOURCE: National Science Foundation/Division of Science Resources Studies; table B-6.

With regard to performance, universities and colleges (excluding FFRDCs) account for the largest share (51.1 percent) of the projected basic research total for 1998. When the performance of university-administered FFRDCs is included, the academic sector's share climbs to 58.9 percent. In 1998, basic research performance of universities—excluding FFRDCs—reached an estimated $17.6 billion in current dollars , representing a 3.3-percent increase from 1997 in real terms. By preliminary calculations, the Federal Government provided 62.5 percent of the basic research funds used by the academic sector in 1998. Non-federal sources—including industry, state and local governments, universities and colleges themselves, and nonprofit organizations—provided the remaining 37.5 percent.

Applied Research

The estimated average annual real growth in applied research performance was 7.3 percent between 1980 and 1985, 0.8 percent between 1985 and 1994, and 5.6 percent between 1994 and 1998 (by preliminary estimates for 1998). Increases in industrial support for applied research were behind much of this growth. Industrial support accounted for 63.6 percent ($31.7 billion) of the 1998 preliminary total for applied research, and Federal support for 30.0 percent ($14.9 billion).

During the eighties, Federal support for applied research had been intentionally deemphasized in favor of support for basic research. Even with the current administration's increased support of generic/precompetitive applied research, preliminary estimates of Federal support in 1998 for applied research were only 76.3 percent of that for basic research ($14.9 billion vs. $19.5 billion, respectively), as reported by research performers.

Preliminary calculations indicate that 70.0 percent ($34.8 billion) of the Nation's applied research was performed by industry and industry-administered FFRDCs in 1998. Non-federal sources accounted for most ($30.7 billion) of these funds, while Federal sources provided the rest ($4.1 billion).

For the Nation's nonindustrial applied research in calendar year 1998, preliminary data indicate most was performed by universities and colleges and their administered FFRDCs ($7.7 billion) and the Federal Government ($5.1 billion). Approximately 18.9 percent of the projected Federal intramural applied research in FY 1998 was performed by DoD, another 24.4 percent by HHS, and 10.9 percent by NASA.[28] Total Federal applied research performance has been remarkably level over the past 32 years, experiencing only a 0.4-percent average annual growth, in real terms, since 1966.

Development

Since R&D expenditures are primarily expenditures on development, historical patterns of development expenditures mirror historical patterns of total R&D expenditures. From 1980–85, development grew on average by 7.0 percent per year in real terms as larger shares of the national R&D effort were directed toward defense R&D, which tends to be approximately 90 percent development. Between 1985 and 1994, on the other hand, development in real terms grew at an average annual rate of only 0.4 percent, from $74.4 billion in 1985 to $103.0 billion in 1994. Between 1994 and 1998, by preliminary estimates, annual growth was back up to 5.0 percent in real terms, to $136.4 billion in 1998, of which 75.7 percent was supported by industry and 23.6 percent by the Federal Government. In terms of performance, industry (including industrial FFRDCs) accounted for 89.7 percent ($122.3 billion) of the Nation's 1998 development activities, the Federal Government 6.5 percent ($8.9 billion), and all other performers 3.8 percent ($5.2 billion).

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[28] These percentages were derived from preliminary Federal obligations as reported in NSF, *Federal Funds for Research and Development: Fiscal Years 1996, 1997, and 1998*, NSF 98-332.

R&D Scientists and Engineers

NSF sponsors a variety of surveys designed to collect data on the human resources devoted to science and technology in the United States, including information on worker inputs for R&D. Surveys directed at *employers or institutions* focus on the amount of time devoted to the performance and management of R&D. These data are reported in terms of person-years, or full-time equivalent (FTE) R&D jobs. Surveys directed at *individuals* collect data on self-reported primary work activity; that is, the activity on which a scientist/engineer spends the largest proportion of time but that is not necessarily full-time. The *1994 National Patterns* was the first to include revised estimates of the total number of scientists and engineers (S&Es) engaged primarily in R&D activities. The national totals include an FTE count of S&Es employed by industry, the total number of Federal employees whose primary work activity is research or development, an FTE estimate of graduate students' research activity, and the number of doctorate-holding S&Es working in educational or nonprofit organizations who self-report their primary work activity as research, development, or (up to 1993) the management of R&D work. These concepts are further described in appendix A.

National Estimates of R&D Scientists and Engineers

Approximately 987,700 scientists and engineers were employed in 1995 on R&D activities in the United States (appendix table B-27). This figure reflects an annual growth rate of 1.3 percent from the 1993 level of 962,700. It reflects a 2.1-percent annual growth rate over the 1985 figure of 801,900, the first year for which revised national tabulations have been derived.[29]

In 1995, industry employed 79.9 percent of these R&D personnel. Transportation equipment accounted for 17.6 percent of the industry total (789,500), and nonmanufacturing for 27.0 percent. This stands in sharp contrast to only eight years earlier, 1987, when the transportation equipment industry had nearly twice as many R&D S&Es as nonmanufacturing (187,800 versus 99,200, respectively). The Federal Government employed 5.5 percent (53,900) of the Nation's R&D S&Es in 1995, while the academic and nonprofit sectors accounted for the rest.

In 1981, the number of scientists and engineers engaged in R&D per 10,000 labor force was just under 62. This ratio climbed continually through the 1980s, reached a peak of 76 per 10,000 in 1991, and has not changed significantly since then.

These personnel estimates make it possible to gain a rough perspective on the changing cost of doing research. In 1985, the Nation spent an average of approximately $143,000 on R&D per R&D scientist and engineer, which includes salaries, fringe benefits, materials, supplies, and overhead for R&D activities. By 1995, this cost rose at roughly the same rate as inflation to $185,000. (See appendix table B-23 for industry-specific ratios.)

Surveys of Doctoral Scientists and Engineers

In 1995, the latest year for available data, there were approximately 484,780 doctoral scientists and engineers employed in the United States (appendix table B-28). This total represents a 2.5-percent annual growth over the 344,000 reported for 1981. Holders of doctorates in sciences in 1995 greatly outnumbered holders of doctorates in engineering, 406,130 versus 78,650 respectively, with the number for sciences including 143,390 under "social and related sciences."

Forty-one percent of all science and engineering doctorate-holders reported R&D as their primary work activity in 1995. Basic research, as a primary activity, accounted for 13.7 percent of all scientists and engineers holding doctorates; applied research 20.2 percent; development 4.9 percent; and design 2.3 percent.[30] Teaching as a primary activity accounted for 22.1 percent of doctoral scientists and engineers, with the remaining

[29] See appendix A for details on the FTE R&D scientists and engineers series.

[30] The category of R&D called "design" refers here to design in the context of engineering, e.g., the design of equipment, processes, structures, and prototype models, as opposed to "design" in other contexts, e.g., the design of entire research programs, expenditures, etc.

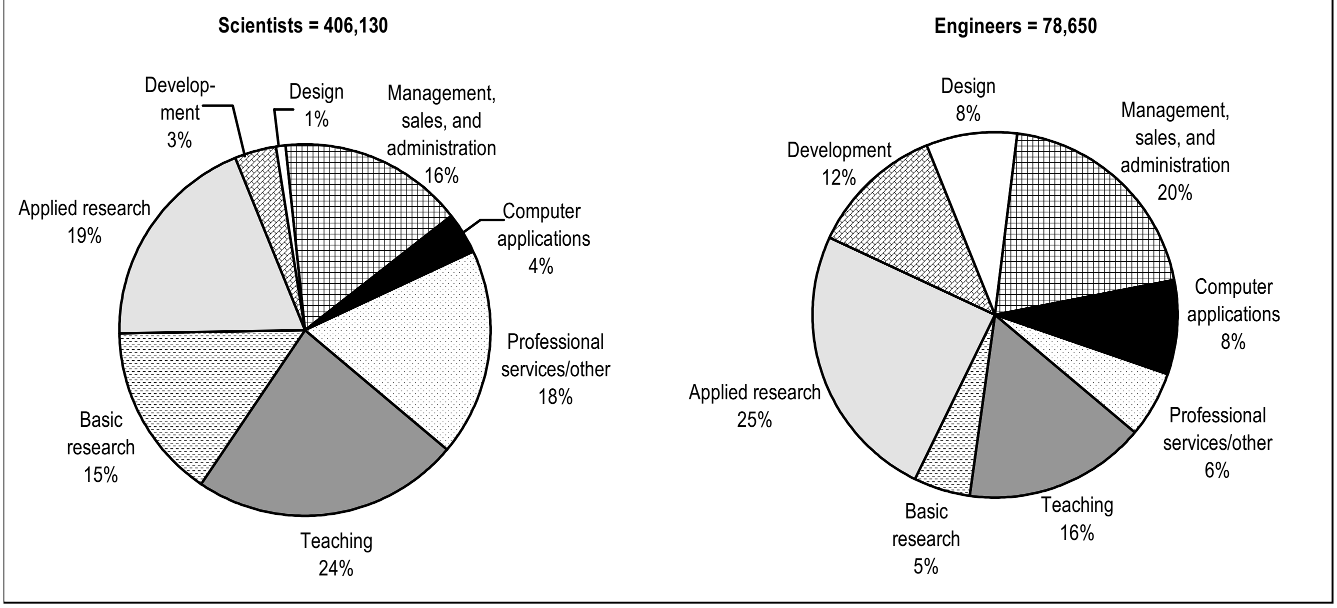
35.7 percent being distributed among management/ sales/administration (16.4 percent), computer applications (4.4 percent), and professional services/other (14.9 percent)[31].

Scientists holding doctorates in 1995 were more likely to have basic research as their primary activity (15.3 percent of all scientists hold doctorates) than engineers holding doctorates (4.9 percent). Consequently, in comparison to engineers, scientists holding doctorates were less likely to have applied research, development, or design as a their primary activity. The respective percentages for doctoral scientists and engineers with regard to these primary activities were 19.3 percent versus 24.8 percent for applied research; 3.5 percent versus 11.9 percent for development; and 1.3 percent versus 7.9 percent for design.

Doctoral engineers reported more involvement in management, sales, and administration as a primary work activity (20.1 percent) than doctoral scientists (15.7 percent). In contrast, scientists reported more involvement in teaching than engineers, i.e., 23.2 percent versus 16.1 percent, respectively (figure 17).

[31] This last category includes "production, operations, maintenance (e.g., truck driving, machine tooling, auto/machine repairing)" and "professional services (health care, counseling, financial services, legal services, etc.)"—see, "Survey of Doctorate Recipients, 1995", page 5, in National Science Foundation, Division of Science Resources Studies, *Characteristics of Doctoral Scientists and Engineers in the United States: 1995,* NSF 97-319, R. Keith Wilkinson (Arlington, VA 1997).

Figure 17. Employed doctoral scientists and engineers, by primary work activity: 1995



SOURCE: National Science Foundation/Division of Science Resources Studies, table B-28.